



ECOLOGICAL OBSERVATIONS ON TWO PUERTO-RICAN ECHINODERMS, MELLITA LATA AND ASTROPECTEN MARGINATUS

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I. *Mellita lata* H. L. Clark

In 1941 Dr. Henry van der Schalie collected two tests of keyhole urchins (*Mellita*) on the beach near Loíza Vieja, Puerto Rico. The tests were later examined by Dr. Hubert Lyman Clark,¹ who recognized them as *Mellita lata* H. L. Clark, a species recently described by him (Clark, 1940) and known previously only from two localities—Puerto Limón, Costa Rica, and La Mancha, Veracruz, Mexico. According to Clark (1933) two species of *Mellita* occur in Puerto Rico—*M. quinquesperforata* (Leske) and *M. sexiesperforata* (Leske). The latter, however, is now placed in the genus *Leodia* Gray. The records of *M. quinquesperforata* are all based on the collections of the "Fish Hawk" expedition which took a total of ten specimens at Ponce, Arroyo, Mayagüez, Puerto Real, and in San Juan Harbor. The collection was studied by Clark (1901) and the specimens were assigned to the species *Mellita testudinata* Klein (a synonym of *M. quinquesperforata*) which name was, at that time, used for all five-lunuled members of the genus *Mellita* from the eastern coasts of the Americas.

Clark's recent revision (1940) of the genus *Mellita* segregates several new forms from the old group of *M. quinquesperforata*. In the light of this critical study, the Puerto-Rican form is now to be transferred to the species *M. lata*.

This species ranks among the most common echinoderms of Puerto Rico. It occurs on sandy beaches along the entire circumference of the island. In addition to the localities listed by Clark (1901, p. 254), it has been found in the following places:

- (1) Beach east of the mouth of Herrera River, east of Loíza Vieja, P. R. Several tests on the sand (coll. H. van der Schalie and the author). (MCZ No. 7972²).
- (2) Beach about $\frac{1}{2}$ mile west of Punta Embarcadero, northwest of Luquillo, P. R. Very numerous in shallow water. (MCZ No. 7997).
- (3) Beach about $\frac{1}{2}$ mile southwest of Punta Santiago, Playa de Humacao, east of Humacao, P. R. Dry tests on shore and living animals in shallow water. (MCZ No. 7984).
- (4) Beach at Las Mareas, 4 miles southwest of Guayama, P. R. (or 1 mile

¹ This study was begun at the suggestion of Dr. Clark, who desired to obtain additional specimens of this seemingly rare form from Puerto Rico, and asked me to gather more information on its distribution and ecology. I am grateful to Dr. Clark for his continued interest in this work.

² Collection of the Museum of Comparative Zoology, Harvard University.

- northeast of Punta Ola Grande). Numerous specimens, close to shore (coll. Gloria Fernández). (MCZ No. 7998).
- (5) Beach near Central Boca Chica, Barrio Cintrona, about 6 miles east of Ponce, P. R. Four specimens, rather fresh, dead on the beach. (MCZ No. 7986).
 - (6) Playa de Maní, 3 miles north-northwest of Mayagüez Harbor, P. R. Five fresh tests on the sand. (MCZ No. 7988).
 - (7) Beach at Punta Cadena, $6\frac{1}{2}$ miles west of Añasco, P. R., in shallow water (coll. Carlos F. Blanco). (MCZ No. 7990).
 - (8) Columbus Park, $\frac{1}{2}$ mile south of Aguadilla, P. R. Very numerous in shallow water, $1\frac{1}{2}$ to 2 feet. (MCZ No. 7989).
 - (9) Cataño Beach in San Juan Bay, 2 miles southwest of San Juan, P. R. (MCZ No. 7999).
 - (10) Isla Verde, east of San Juan, P. R. Three specimens from the collection of the Department of Biology, University of Puerto Rico. (MCZ No. 7973).

In several of these localities, the animals are exceedingly numerous. This may be said, in particular, of Luquillo Beach where they were found to be most abundant close to shore, just below the zone of moving sand, at depths of from one to three feet. Up to 16 animals were counted in a square-foot area.

The people of the island coast, including fishermen, pay little attention to the animal and have no particular name for it. In two places, Humacao and Aguadilla, I heard them referring to *Mellita* as "estrella" which means star and is also the name used generally for sea-stars. Apparently the use of the name is due to the radial pattern of the oral surface.

A general description of the morphology of *Mellita lata* was given by Clark (1940, pp. 437-438, and pl. 60, fig. 1; pl. 61, fig. 1; pl. 62, figs. 1, 2). The species is characterized mainly by its elliptical shape, the width exceeding the length considerably; by the anterior situation of the apex; by the dimensions and the shape of the lunules; and by the large heads of the capitate aboral primary spines.

Color of the living animal.—The aboral surface is dark grayish olive-green. The oral side (Fig. 2) has a remarkable color pattern. In animals from Luquillo, the ambulacral areas are usually dark wine-red, occasionally dark purple, or more rarely a lighter shade of red. Lighter (pinkish), narrow, somewhat branched bands radiate from the peristomial margin towards the inner ends of the paired lunules (I, II, IV, and V) and similarly in the anterior midline (III) towards the anterior margin. More irregular light patches and stripes, extending in a transverse direction, occur on both sides of the unpaired lunule. In specimens taken at Aguadilla, however, the ambulacral areas were brown, the shade ranging from deep yellow-brown to red-brown, and the lighter bands and patches were in a light brown hue. The interambulacra are covered with silvery, translucent spines and appear whitish or light pink.

The color of the dark areas of the oral surface is due mainly to the coloration of the numerous tube feet and that of the periproct with the anal tube. In other places, the epidermis has a light pink or yellowish color.

After the spines and the epidermis of a fresh specimen are removed, the following

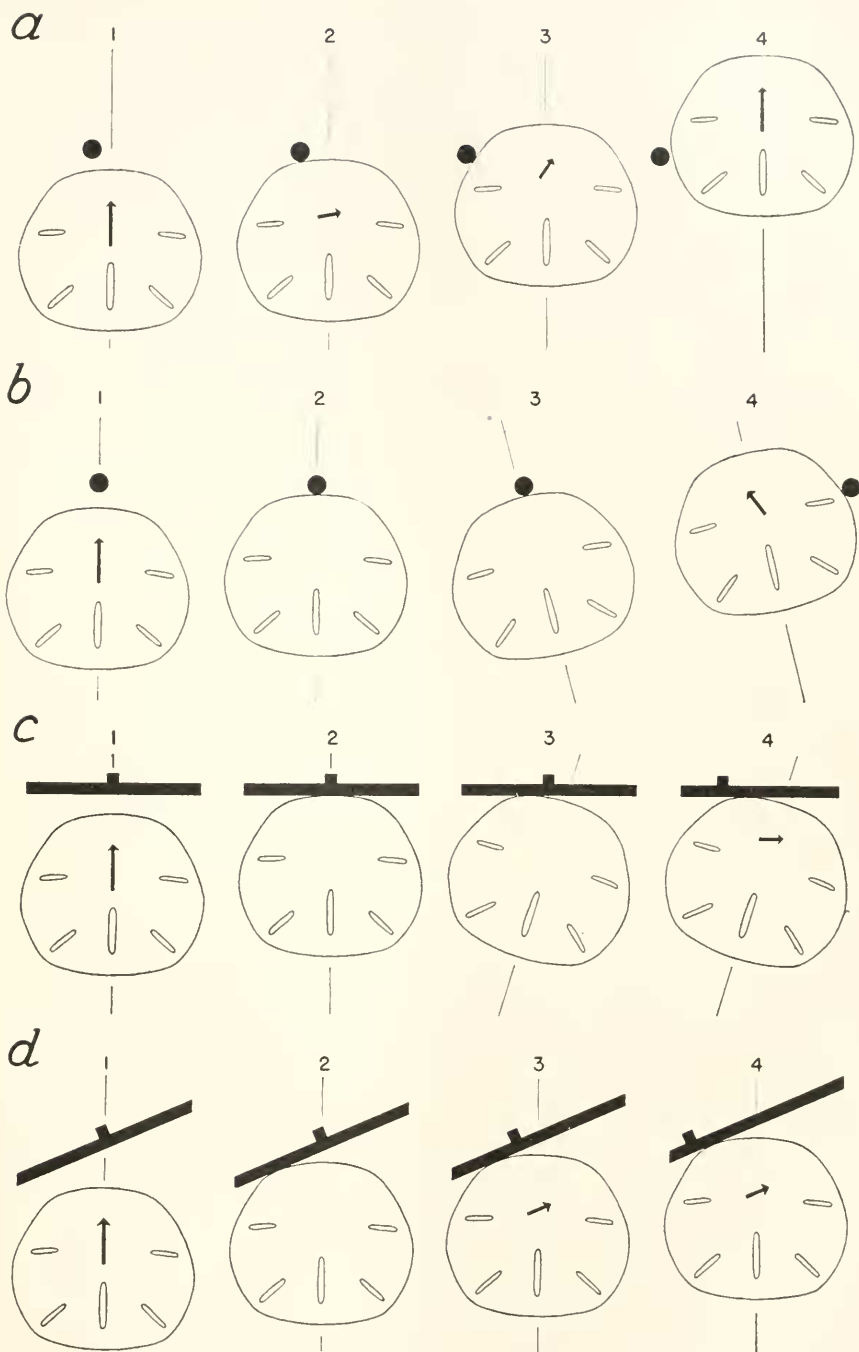


FIGURE 1. Behavior of *Mellita lata* meeting obstacles while digging into the sand: (a), successive positions at running against stick placed vertically in the path of movement, to one side of the midline; (b), stick placed vertically in the center of path; (c), vertical board placed transversally to the direction of movement; (d), vertical board placed obliquely in the path of movement.

color pattern is seen on the exposed test: Aboral side—blue-green; oral side—ambulacral areas brown and the interambulacra white, pink, or light yellow.

The dark coloring matter of the oral side is extracted by the common preservatives (alcohol, diluted formalin) in a very short time.

The anus is situated as the end of a short tube (about three millimeters long in fully grown animals) and is surrounded by small, irregular papillae. The tube feet are closely packed in the ambulacral areas, except in the radial bands of lighter color. Moreover they are found along the margins of all lunules, including the posterior or interambulacral lunule, and also among the marginal spines of the entire circumference.

The oral side has three kinds of spines which may be roughly grouped as follows: Long, slender spines of the interambulacra (these are the ones responsible, together with the marginal spines, for the locomotion of the animal); medium-sized spines scattered over the ambulacral areas; and short spines of the ambulacral surfaces, particularly flanking the ambulacral furrows. No pedicellariae were seen.

Ecology.—The animals live buried in the uppermost layer of the sand in such a manner that usually only the posterior lunule, with a small part of the posterior surface and of the posterior margin, is visible. Occasionally, also lunules I and V may be exposed. Only exceptionally is the contour of the entire animal discernible. They move continuously through the sand, their speed varying from 11 to 26 millimeters per minute.

Experiments on locomotion.—Several individuals were placed on a layer of sand in a flat pan filled with sea water. At first the animals remained quiet and no movement of the marginal spines was seen from the aboral side. After a short time—a few seconds up to perhaps one minute—they began to move forward, first in small jerks and later in continuous movement. They dug obliquely into the sand and disappeared from the surface within a short time, in from one to about four minutes (see Table I and Figs. 4a to 4e).

TABLE I

Time required by Mellita lata to dig in completely. Temperature, 28° C.

Specimen	Length in millimeters	Time required	
		First trial	Second trial
A	25	1 min. 20 sec.	1 min. 30 sec.
B	26	1 min. 25 sec.	
C	36	2 min. 30 sec.	1 min. 45 sec.
D	53	2 min. 05 sec.	
E	60	2 min. 40 sec.	
F	70	3 min. 20 sec.	3 min. 20 sec.
G	71	3 min. 05 sec.	

As the animals move in a forward direction, they need a "runway" of a certain length to dig in successfully. Two specimens placed in a jar with a diameter of about 90 millimeters, were moving around continuously, for hours, but were always on the surface of the sand.

During the digging process, the animals do not react to such mechanical

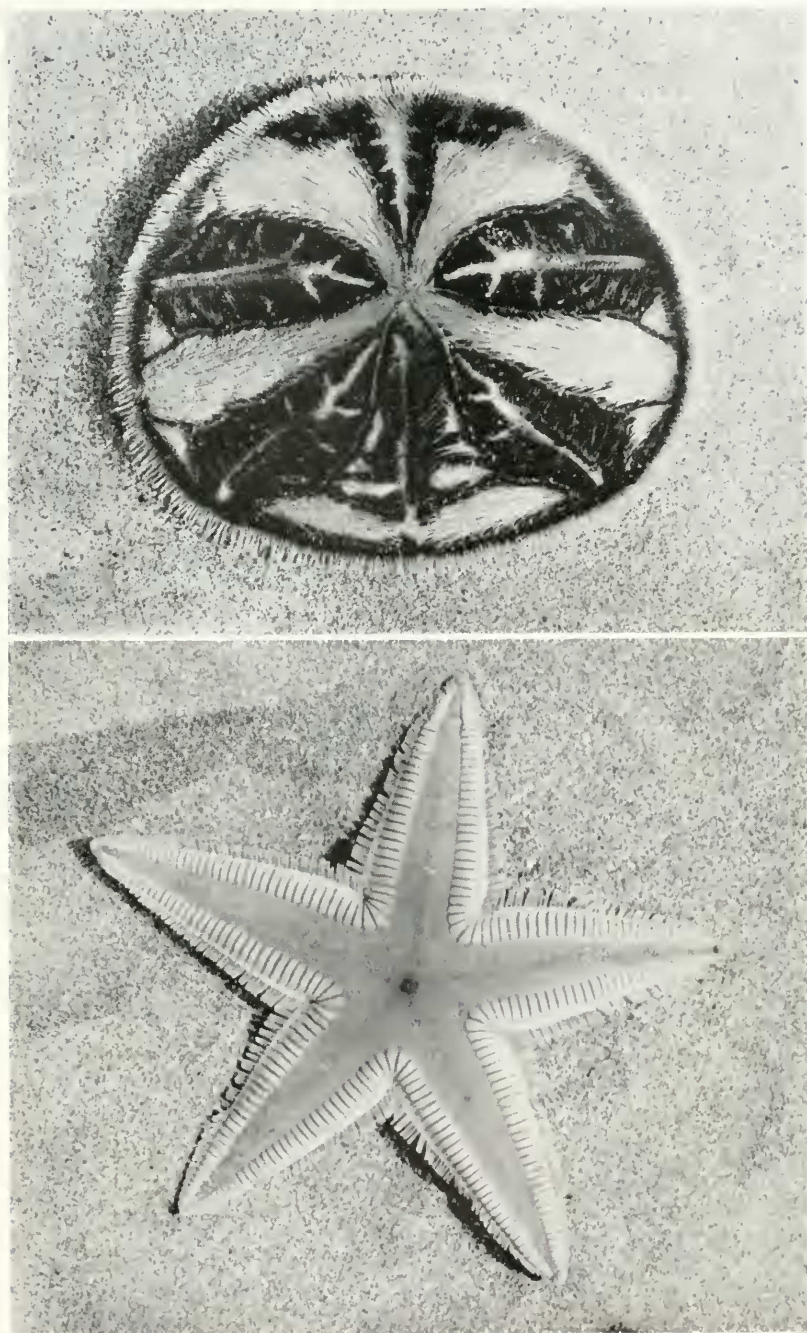


FIGURE 2. *Mellita lata* H. L. Clark, oral side, natural size.

FIGURE 3. *Astropecten marginatus* Gray, aboral side, $\frac{1}{2}$ natural size.

stimuli as tapping the exposed surface with a wooden stick, but continue their locomotion without interruption and at an even rate. If the tapping is so strong as to dislodge the animal from its hold in the sand, the movement is stopped for a short time, to be soon again resumed in the usual way.

The following four experiments have been conducted repeatedly to determine the behavior of a digging animal meeting obstacles placed in its way:

(a) If a stick is placed vertically before the animal, to one side of the midline (Fig. 1a), locomotion is almost stopped when the animal reaches the obstacle, but the rhythmical movements of the spines continue. Slowly the animal works its way around the stick keeping its original orientation all the time (*i.e.*, the antero-posterior axis remains parallel to the original direction of motion as the animal shifts to the right or left, depending on the location of the obstacle with respect to the midline).

(b) When a stick is placed vertically at the center of the frontal margin (Fig. 1b), the animal at first stops its locomotion, but continues to move its spines. Within a short time, the pushing of the spines of one side—the right or the left—prevails and the animal turns slowly towards the weaker side. It then continues to move with an orientation of the axis which is at a slight angle to the original direction.

(c) If a vertical board is placed transversely in the path of movement (Fig. 1c), the animal continues the movement of the spines upon reaching the plane. Slowly it turns to the right or left, for approximately 16 degrees. Then it continues moving laterally along the plane, at a very slow rate, but retains the axis constantly in the new orientation.

(d) When a vertical board is placed obliquely (at an angle of less than 74 degrees) in the path of the movement (Fig. 1d), the animal continues to move, at very slow speed, towards the open side, without rotating its antero-posterior axis.

If two animals collide, head-on, while digging into the sand, the stronger individual may push the weaker one back for a short distance. Finally, one of the animals usually crawls over the top of the other. It is obvious that, on account of the great density of the *Mellita* population on some beaches, such meetings must be of very frequent occurrence.

If an animal is placed on the sand, oral side up, in quiet water (e.g., in a shallow dish), it is capable of very slow forward movement, but it neither can turn into its normal position nor dig into the sand. In moving water, however (in the wave zone of the beach), it is soon turned over by the current and then remains in its right position. This recovery is obviously due to the general shape of the body (concave oral surface, convex aboral side).

One specimen of *Mellita lala* was placed in a glass dish containing sea water and a very thin layer of sand, so that it could be observed from both the oral and aboral sides. It could be seen that the locomotion is accomplished by rhythmical movements of the long spines of the body—the marginal spines, spines of the interambulacra 1, 2, 3, and 4, and the spines of the fields on both sides of the posterior lunule (5). The movement of the spines in each area is metachronal, progressing like a wave in a wheat field. The rate of beating is approximately the same in all areas, about 35 strokes per minute in the animal examined (at 26.5° C.).

Little is known so far about the ecology and the locomotor activities of allied



FIGURE 4. Photographs of *Melittia lata* digging into the sand, taken at various times after the beginning of the movement: (a), after 10 seconds; (b), after 30 sec.; (c), after 55 sec.; (d), after 105 sec.; (e), after 140 sec.

species of the family Scutellidae or sand-dollars. Observations by Pearse *et al.* (1942, p. 150) on *Mellita quinquiesperforata* (Leske) at Beaufort, North Carolina, indicated a behavior rather different from that exhibited by our species: "The sea urchins, *Moiria* and *Mellita*, also move almost directly downward by rapidly waving their spines and tube feet so as to move sand from underneath their tests toward the

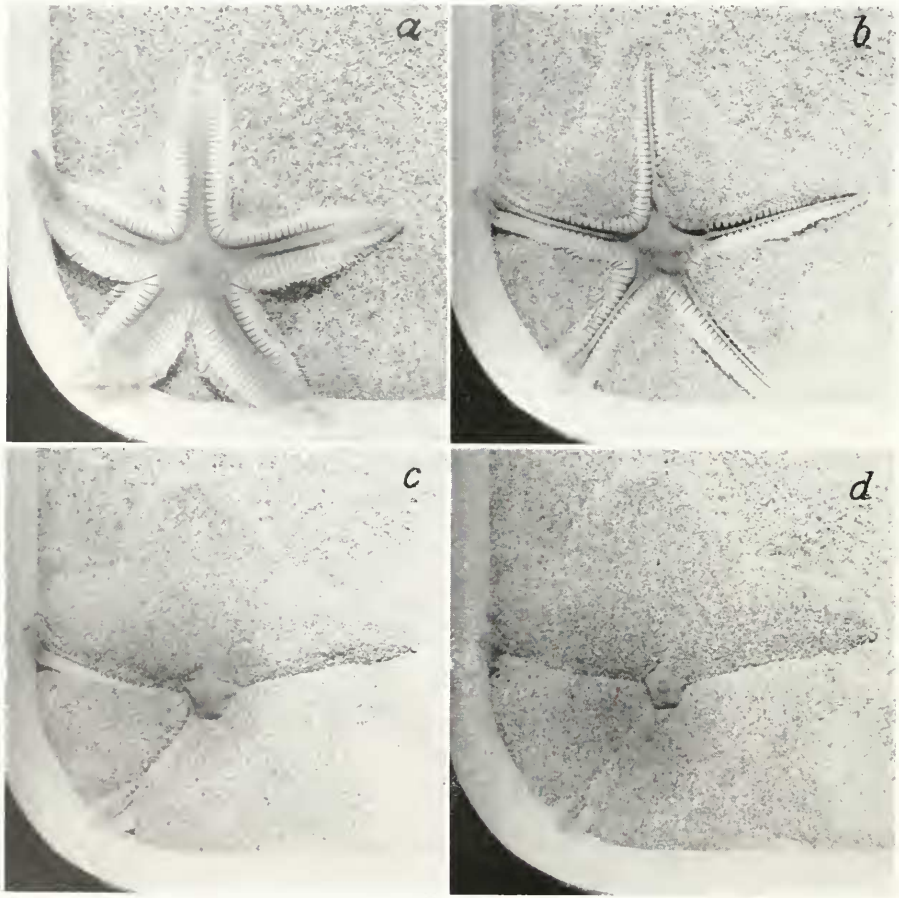


FIGURE 5. Photographs of *Astropecten marginatus* digging into the sand, taken at various times after the beginning of the movement: (a), at start; (b), after 25 seconds; (c), after 45 sec.; (d), after 65 sec.

margins; then move it from the margins so as to cover the upper surface; neither sea urchin makes progress anteriorly as it descends." This mode of movement appears, however, to be exceptional among the sand-dollars. Generally they burrow in a forward direction as *M. lata* does. This method of burrowing has been observed in *Leodia scriessperforata* (Leske) by Crozier (1920); in *Echinarachnius parma* (Lamarck) by Parker (1927) and Parker and van Alstyne (1932); and in

E. mirabilis (A. Aggassiz) and *Astriclypeus manni* Verrill by Ikeda (1939, p. 77). In the speed of burrowing, *M. lata* exceeds all its relatives that have so far been observed. *Leodia scapi perforata* is reported to disappear in the sand in "less than 15 minutes" (but may require two or three times that long), and *Echinarachnius parma* in 10 to 20 minutes.

Rotating movements, either a turning movement with the mouth as center, or a swinging of the anterior end to the right or left during forward locomotion, have been reported in all species so far studied. *M. lata*, however, seems to lack this type of movement, or at least does not exhibit it to a noticeable degree. The body axis is turned only when the animal encounters an obstacle to its forward movement. Horizontal locomotion in a backward direction, such as Ikeda reported for *Echinarachnius mirabilis* and *Astriclypeus manni*, has not been observed in *M. lata*. Our form also lacks the ability to right itself after having been placed on the sand oral side up, while related species generally possess this ability.

One is tempted to correlate the shape of the test of *Mellita lata* with the normal locomotion of the animal, in the uppermost layer of the sand. In a median section through the animal, the greatest height is seen nearer to the anterior margin. The median section thus has a "streamlined" contour. This is obviously the contour that offers the least resistance to the forward movement. With regard to this streamlined shape, the species *lata*, as well as *M. longifissa* Michelin and *M. latiambulacra* H. L. Clark in which the general form is similar, appear to be more highly specialized and better adapted to their peculiar way of living, than are other species of the genus *Mellita* in which the apex has a more central position.

II. *Astropecten marginatus* Gray³

Clark (1933, pp. 16-19) listed two species of *Astropecten* from Puerto Rico, *A. duplicatus* Gray and another species that he had originally (1901) called *A. antillensis* Lütken, but that he later was inclined to consider identical with *A. articulatus* (Say). While observing *Mellita lata*, I found, in the same habitat, *A. marginatus* Gray, a species hitherto unrecorded in the Greater Antilles. It was identified by H. L. Clark.

A. marginatus (Fig. 3) was repeatedly collected at Luquillo Beach, about one-half mile west of Punta Enbarcadero, northwest of Luquillo, Puerto Rico. It lives there buried in the sand and shares its habitat with the much more abundant keyhole urchin. It does not come as close to shore as *Mellita* does, but is more numerous in the deepest water accessible by wading (four to five feet). In the collection of this sea-star I was very ably assisted by Mr. Víctor A. Marcial. The animals were obtained by probing the sand with the hands or feet while wading. Only a few were seen on the surface of the sand. Several specimens were deposited in the Museum of Comparative Zoölogy, Cambridge, Massachusetts (Nos. 4109, 4110, 4113 and 4114).

The known geographic range of *A. marginatus* comprises the coasts of Venezuela, Trinidad, Guiana, and Brazil as far south as 27° 30'. It appears, therefore, probable that the species reached Puerto Rico via the Lesser Antilles, an assumption that Dr. Clark would extend also to *Mellita lata*.⁴

³ Gray, 1840, *Ann. Mag. Nat. Hist.*, 6: 181.

⁴ Personal communication.

Color in life.—In a great majority of about 30 specimens collected, the aboral side was a beautiful blue-green, of various shades, darkening towards the tips of the arms. This color extended both over the superomarginals (with their marginal spines) and the paxillar area. The center of the disk had a small, round brownish spot. Only two individuals exhibited an aberrant coloration, a yellow-brown aboral surface. The oral side is creamy white, with the ambulacral feet showing a very faint tint of brown.

The blue-green coloring matter of the aboral side is remarkably unstable. When animals were placed in alcohol, they rapidly turned brown-yellow. This change was clearly visible within one minute. Later the brownish color dissolved and stained the alcohol, while the specimens became white. In diluted formalin the color is altered more slowly, but is lost within a few days. It is possible that the green and brown coloring materials represent only modifications of the same pigment. If so, the two brown specimens mentioned may not be as strikingly aberrant as they would otherwise appear to be.

Freshly caught specimens, placed in a dish filled with sea water and sand, move at first rather fast over the surface of the sand, preferably along the walls of the dish. In this movement, the body is lifted up and supported by the tube feet in the way repeatedly observed in other species of *Astropecten* (Romanes and Ewart, 1882, p. 839, etc.).⁵ Later, they come to rest, usually in a corner. After staying there for a time, they begin to dig into the sand, perpendicularly and simultaneously with all five arms. Figures 5a to 5d show successive stages of this digging activity. The process is surprisingly fast and the animal photographed would have been completely covered within one minute, had it not reached the bottom of the dish and come to rest when the ends of the arms and the central part of the disk were still exposed.

The digging is done by movements of the tube feet. At first, the margins of the arms are bent upwards rather steeply, so that the marginal spines assume a vertical position. The paxillar area of each arm is folded into a deep furrow and the arm becomes very narrow. Then sand is seen coming up from the deeper layers along the margins of the arms.

SUMMARY

The common Puerto-Rican keyhole urchin, *Mellita lata* H. L. Clark, and the sea-star, *Astropecten marginatus* Gray, live in the uppermost layers of the sand of shallow beaches. The color in life, and various locomotor activities of the two species are described.

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⁵The speed of this "running," though not actually measured, exceeds considerably the velocity of "between one and two feet per minute" that Romanes and Ewart record for *A. aurantiacus* (L.).

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